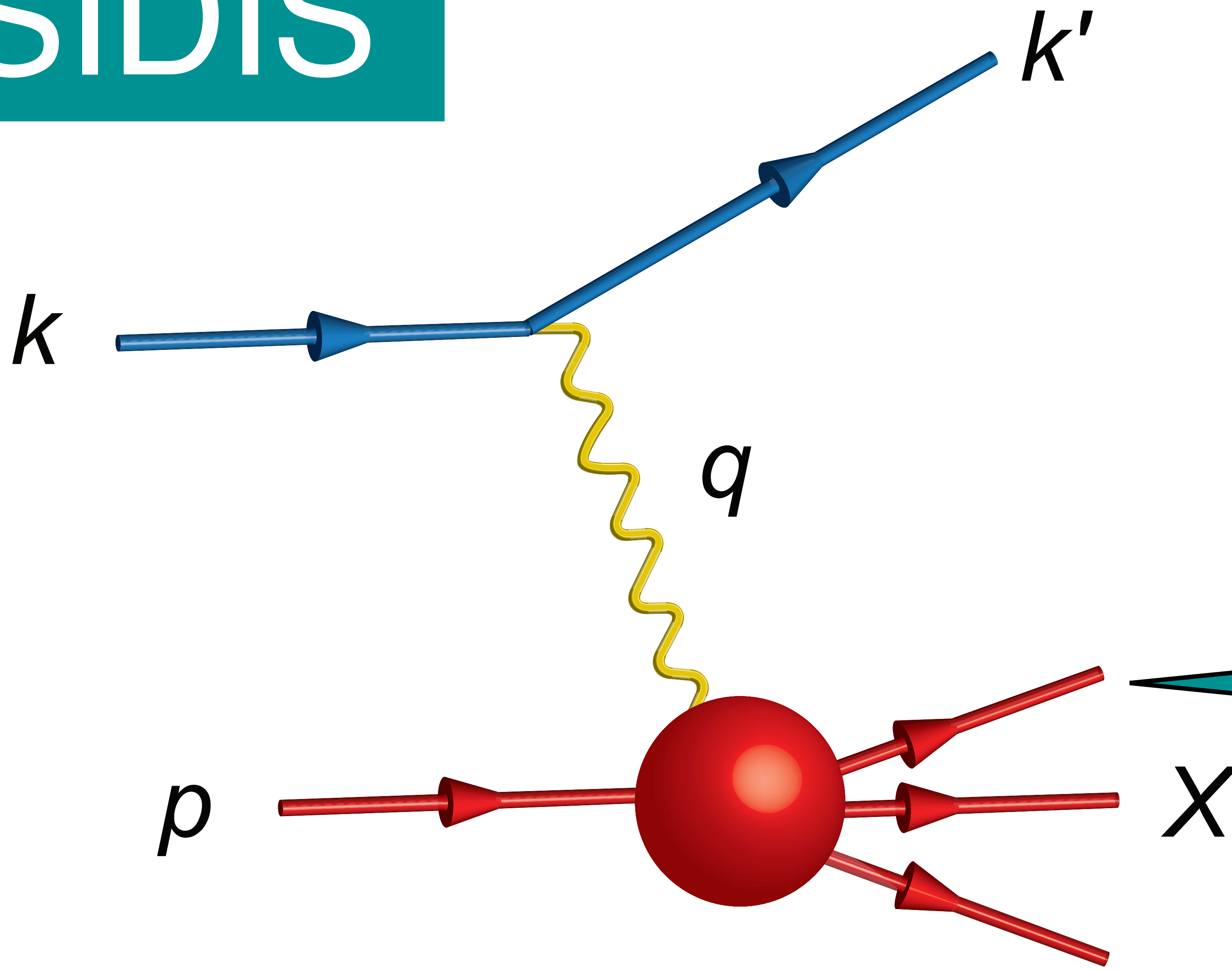
Detector constraints from semi-inclusive reactions

Thomas Burton

EIC R&D Simulation Workshop
Brookhaven National Lab
Monday 8th October 2012

SIDIS



Semi-inclusive DIS

measure electron
+ a hadron

characterise via
(z, p_T)

DIS
x, Q^2

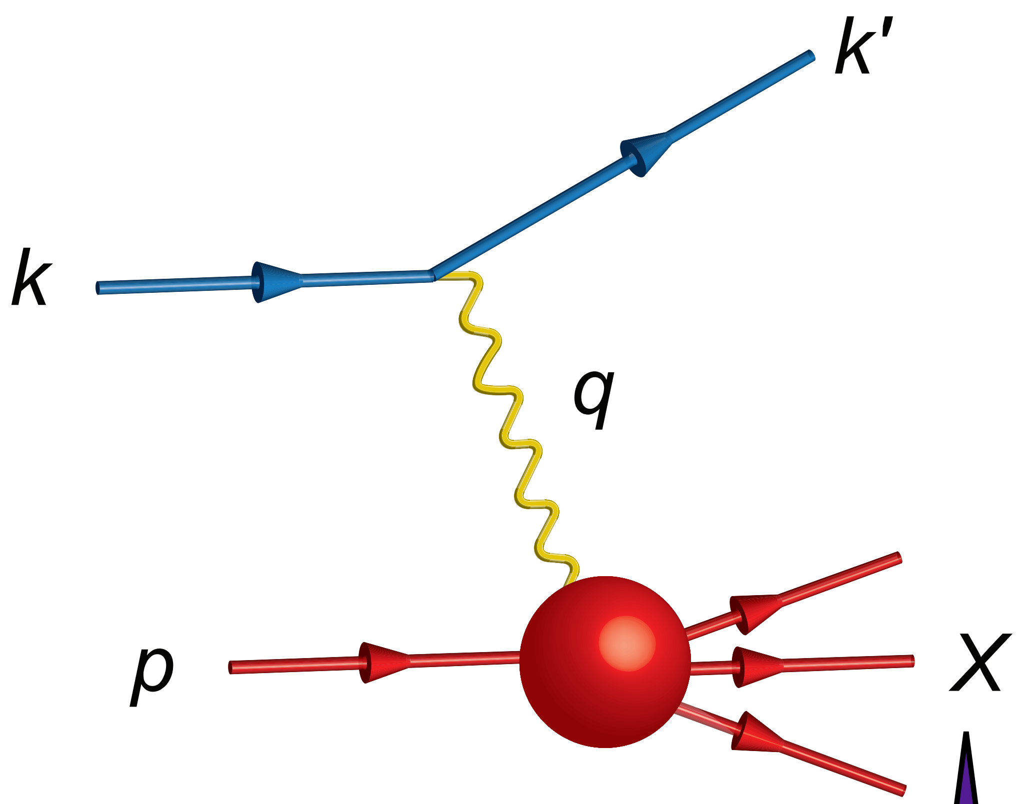
+

semi-
inclusive
z, p_T

(+ spin
ϕ)

⇒ Multi-
dimensional

What do we learn?



(1)
p_T-dependent distributions
“TMD”s
→ transverse imaging in momentum space

(2)
Hadron ‘tags’ struck parton:
flavour separation of spin

Key EIC strengths for SIDIS

1. **Luminosity**: precise, multi-dimensional measurements
2. **Polarisation**: spin-dependent functions
3. **High-E** (vs. fixed-target): access sea

The machine gives us **potential**
...but need the detector for **delivery**

→ EIC **strengths** are also **demands** on detector performance

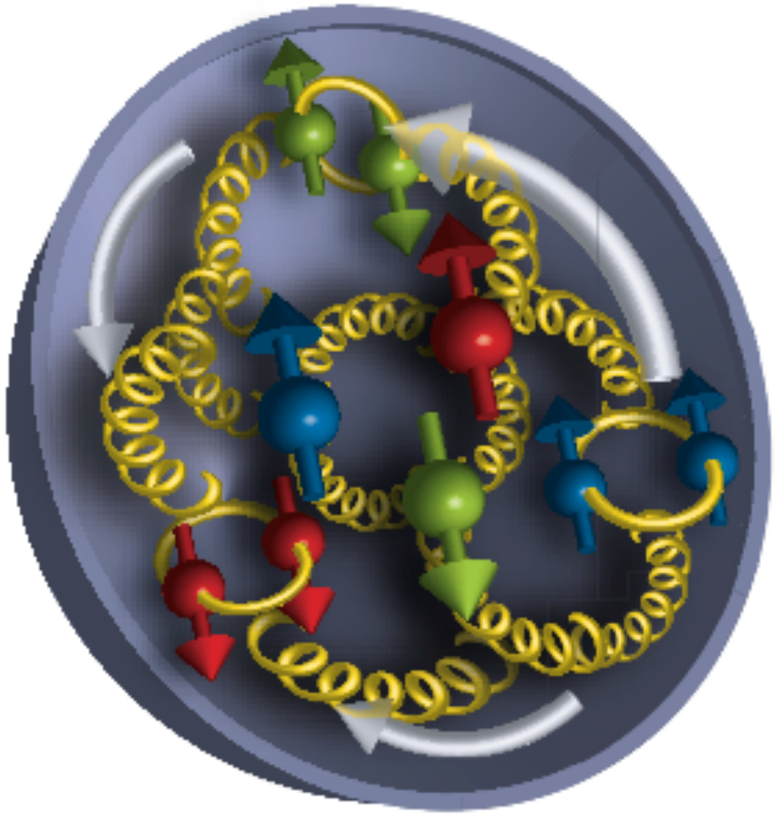
EI(sea)

- Flavour + TMDs already investigated in valence region
  - we will improve there (luminosity!)
  - ...but sea is where we make novel measurements

➡Need low x (~10^{-4}) and *Q^2 lever arm @ low x*

x-Q^2 correlated: small x implies small Q^2

→ want precise reconstruction to small (x, Q^2)

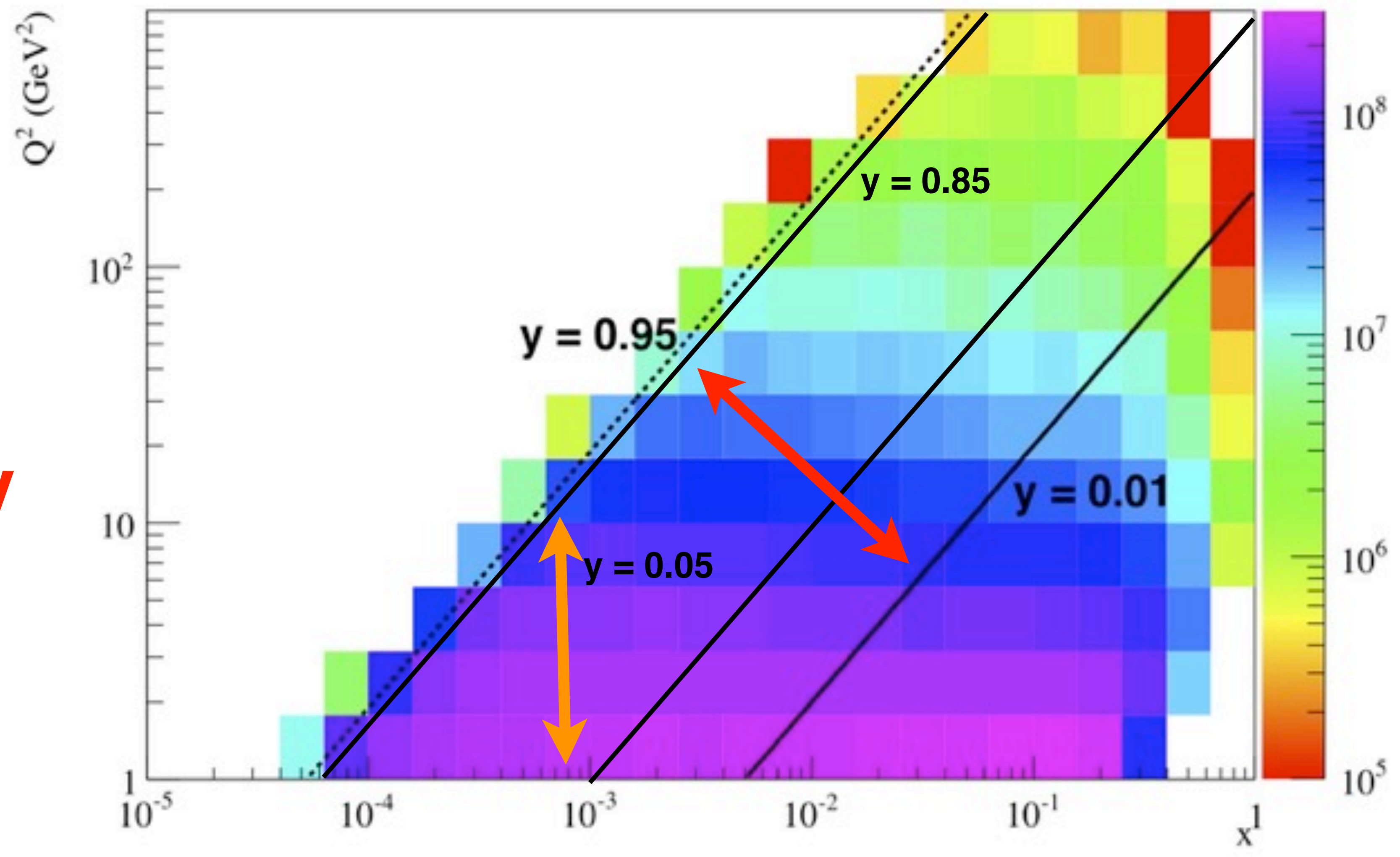


Q^2-x resolution

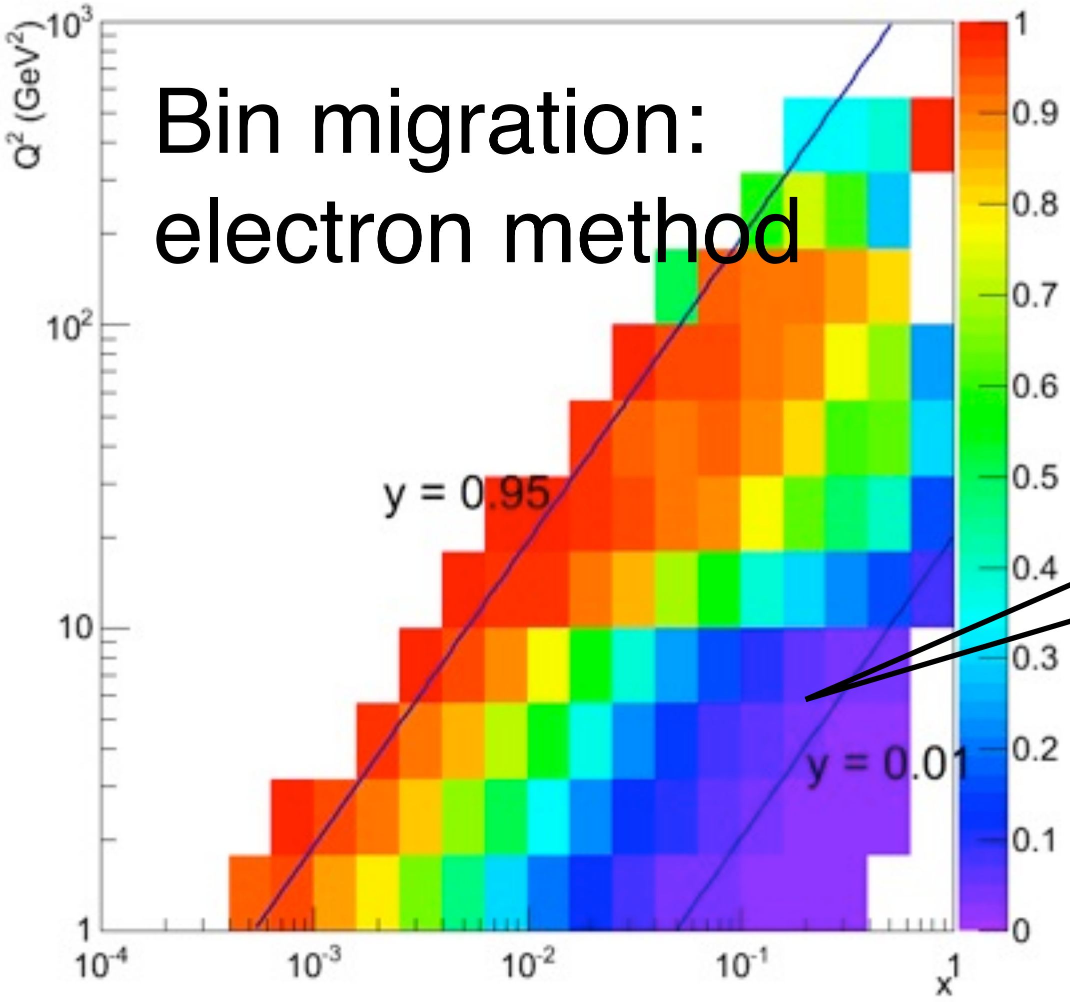
- Using electron, Q^2 precision depends on electron momentum precision
  - small p limit is due to scattering → **low material**
  - large p limit is due to p resolution → **good tracking**

Q^2 **lever arm**

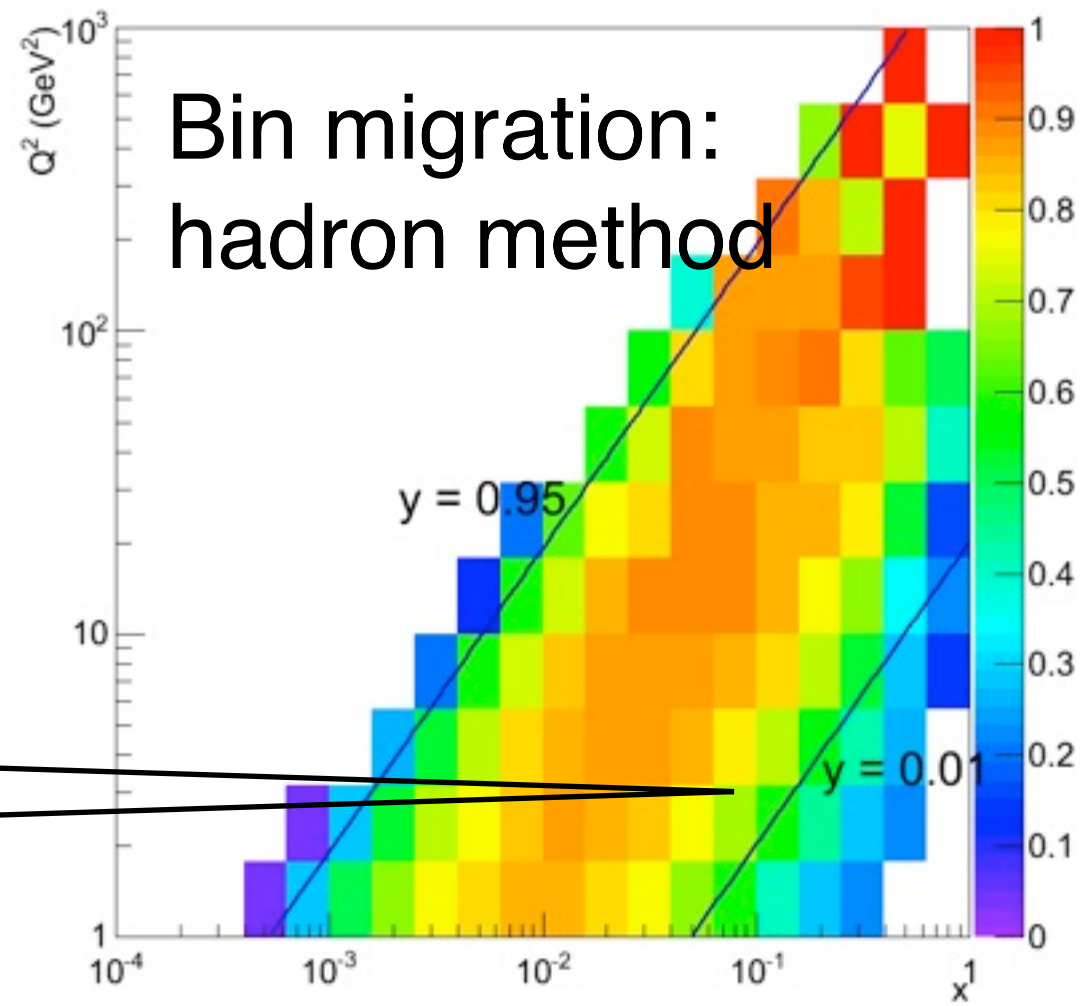
needs **span in y**



Q²-x resolution

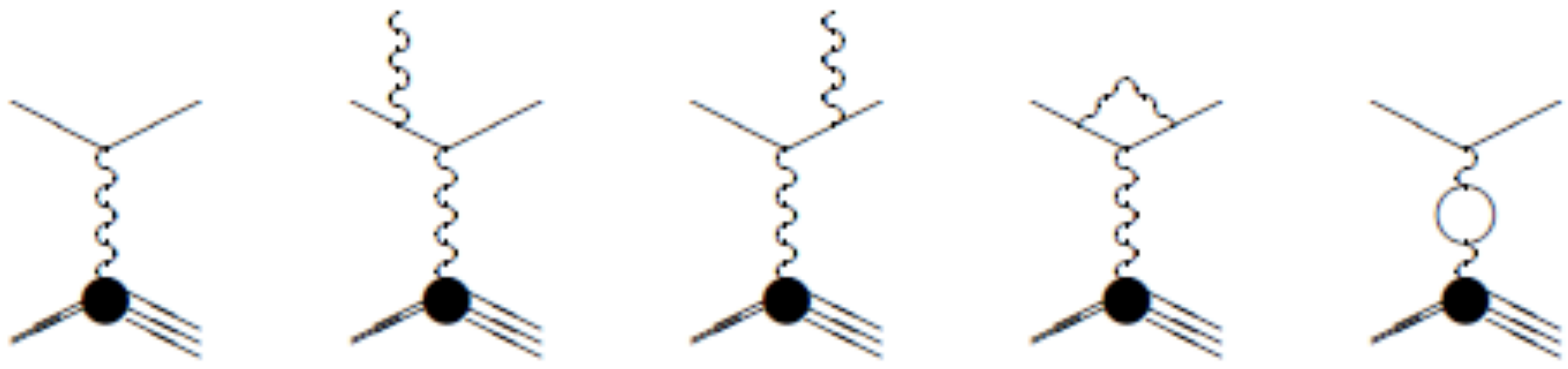


Electron method:
low y limited by resolution



Can use **hadron method**:
hadron acceptance and
momentum resolution
become important

Radiative corrections

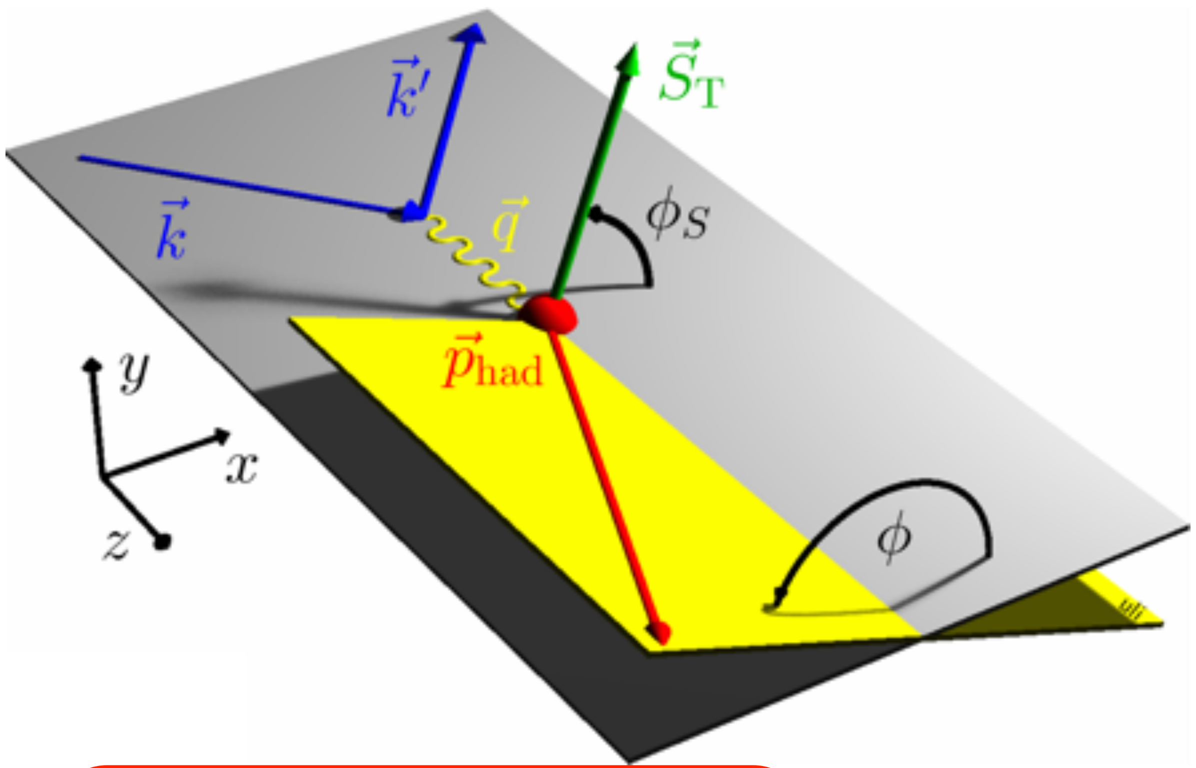


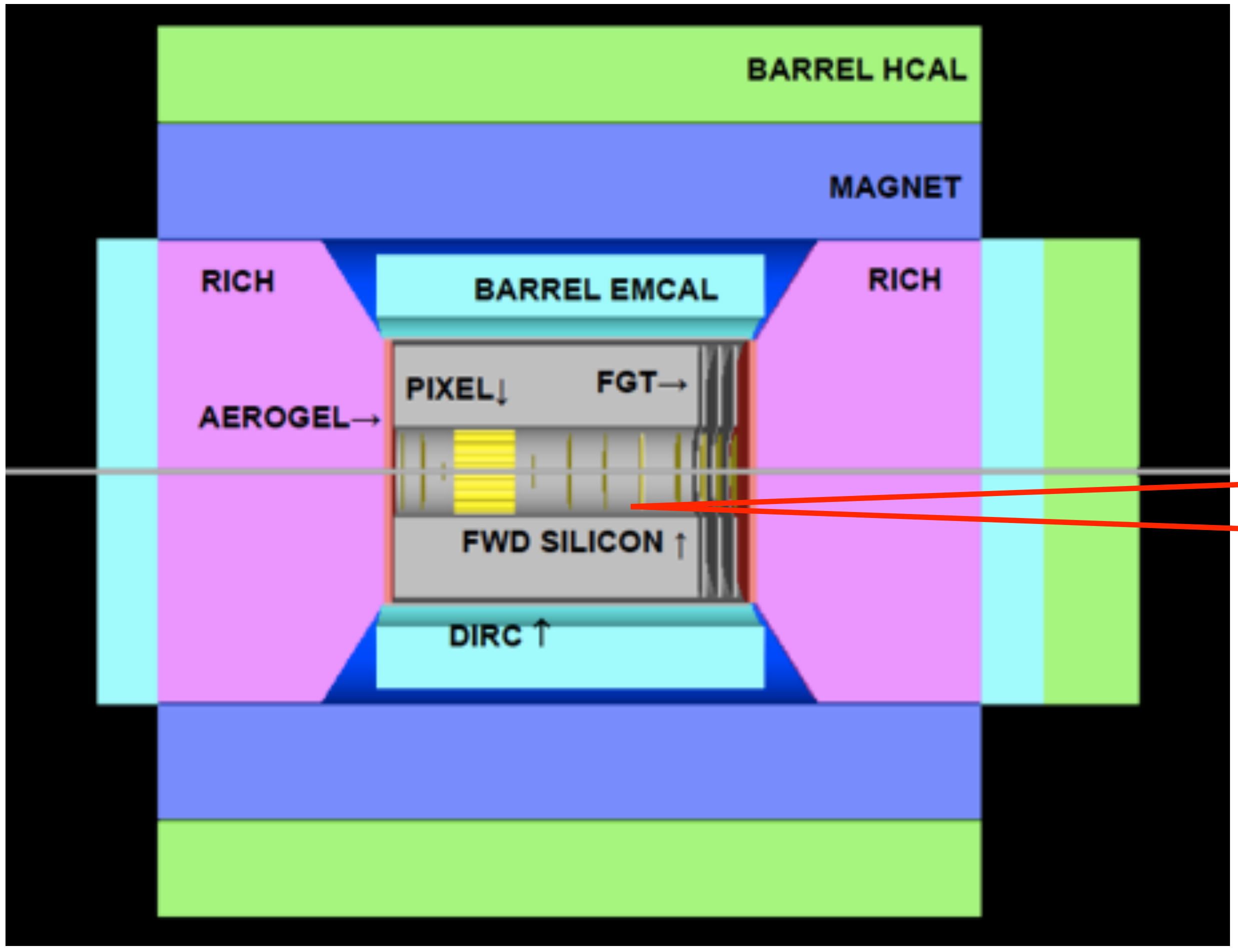
➡Measured (x, Q^2) not actual (x, Q^2)

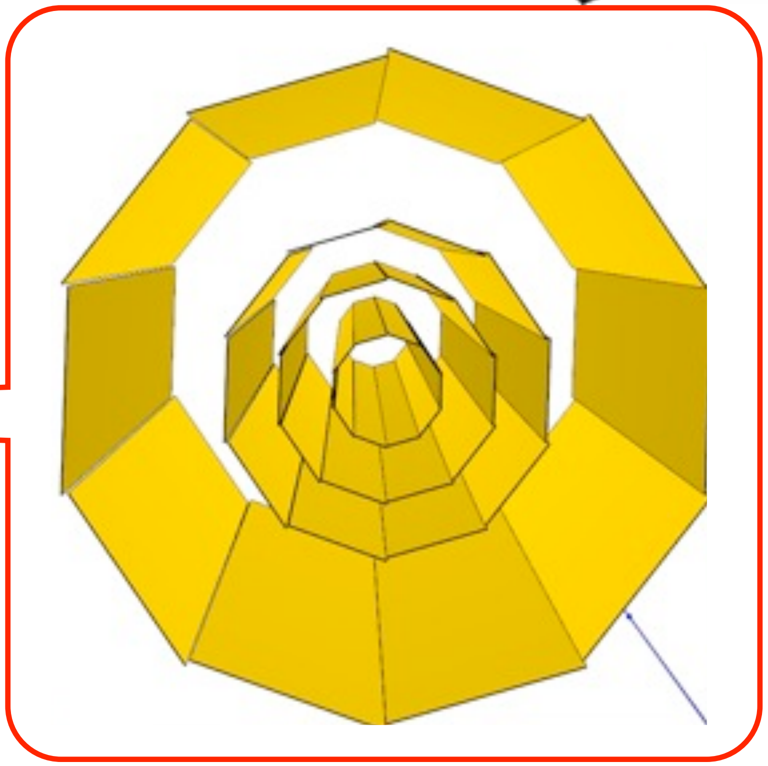
- understood from HERA
  - need it in MC to account for effects

Azimuthal acceptance

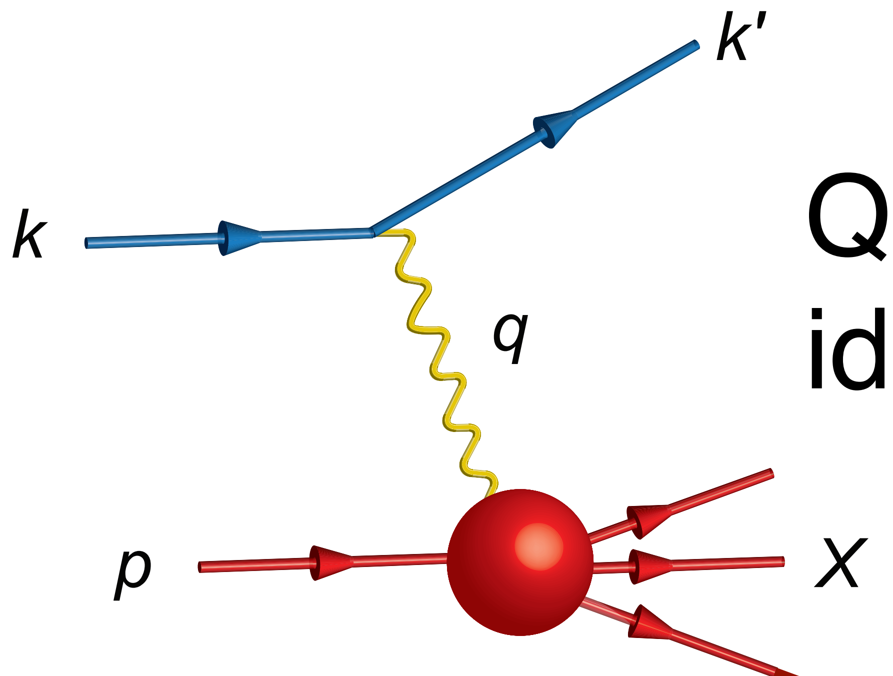
- Spin: measure azimuthal distributions
- Want uniform acceptance around *gamma* - as close to hermetic as possible







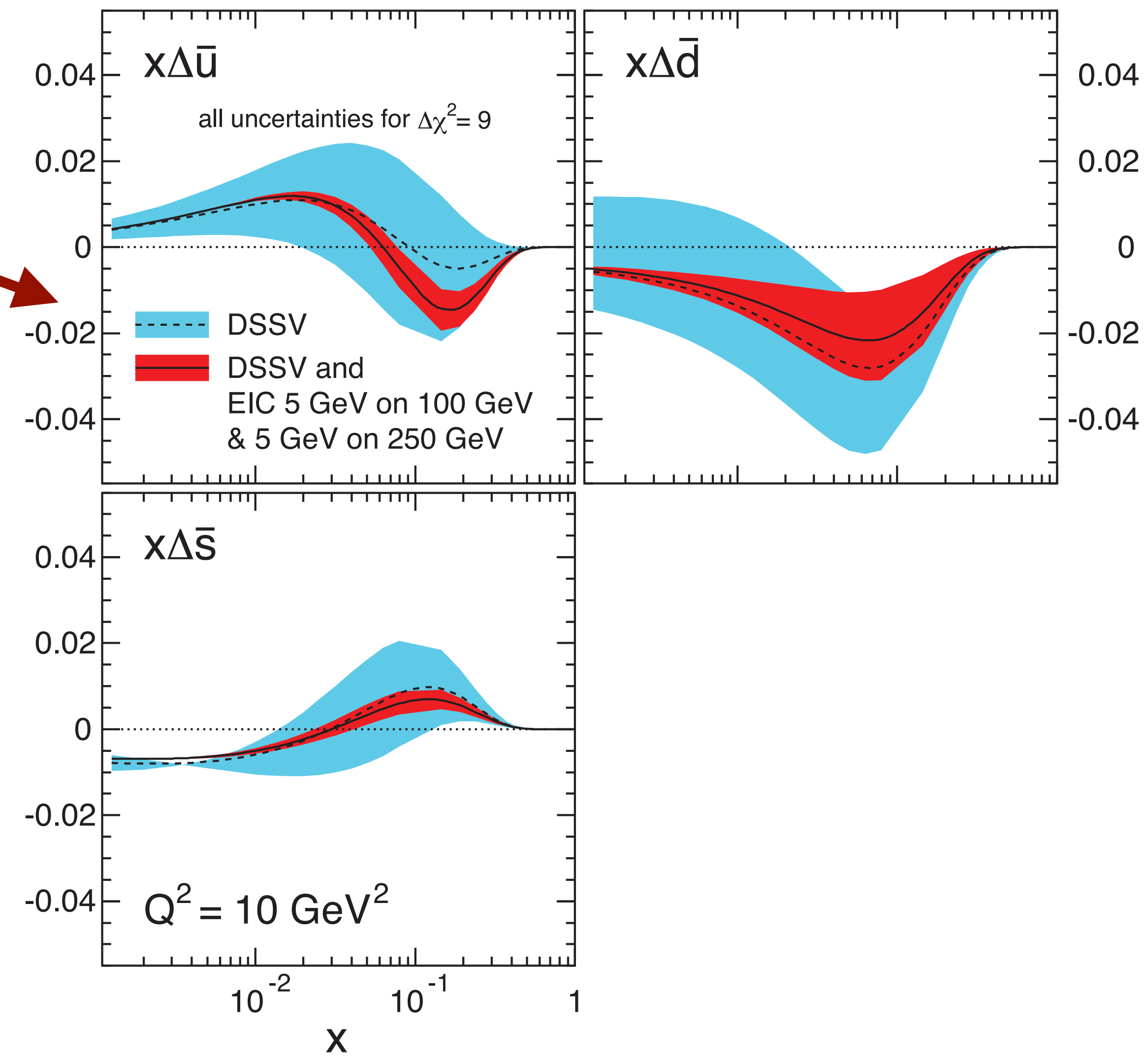
Flavour separation



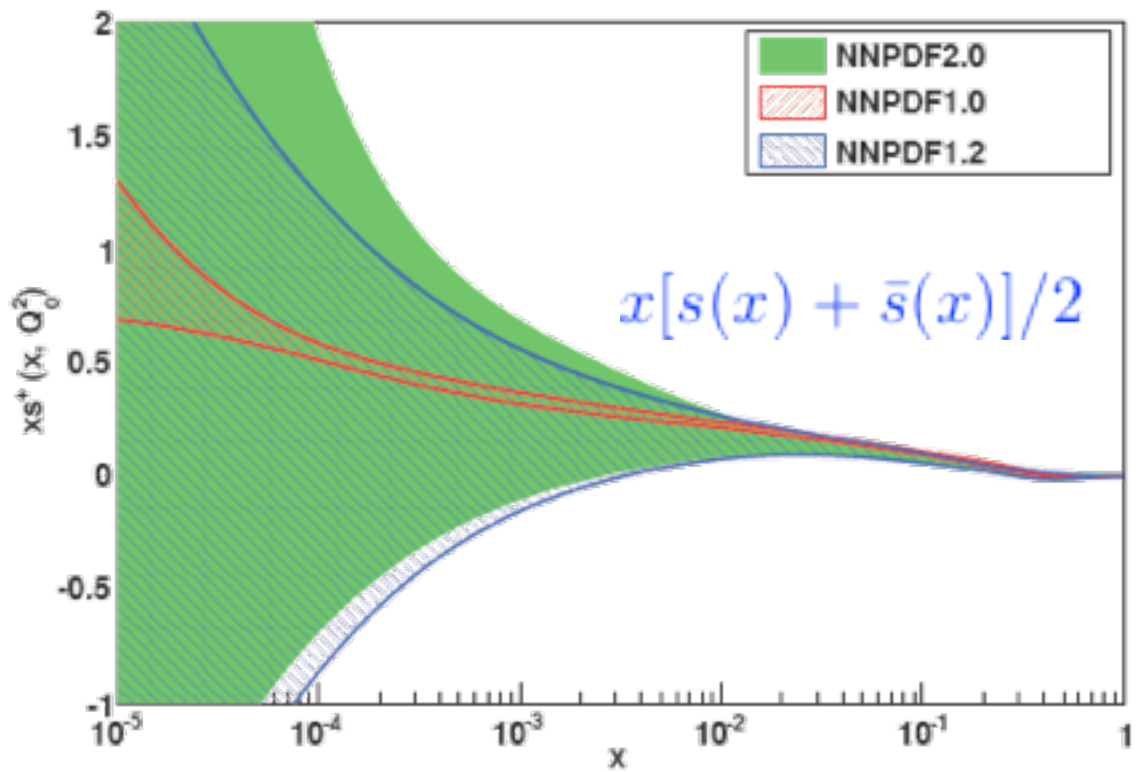
Quark flavour separation:
identified **hadrons** ‘tag’ **flavour**

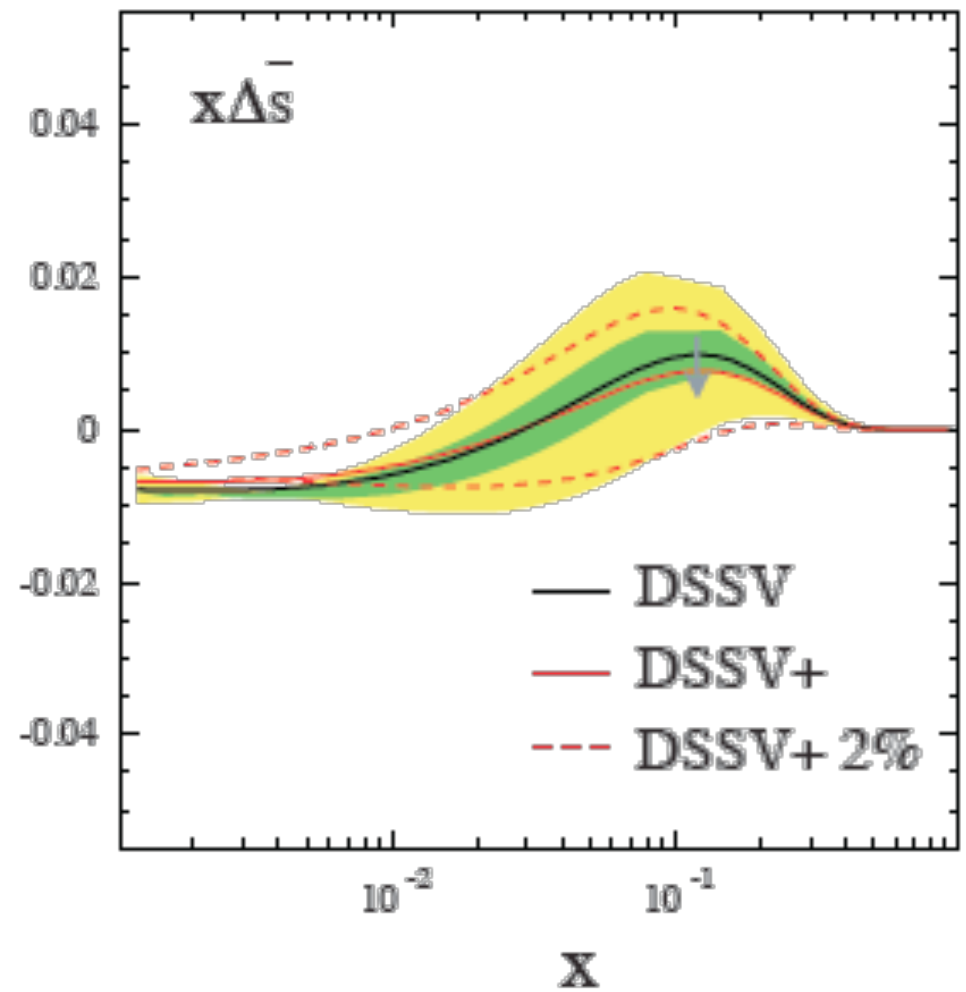
π^+
π^-
K^+
K^-

u
ubar
d
dbar
s
sbar



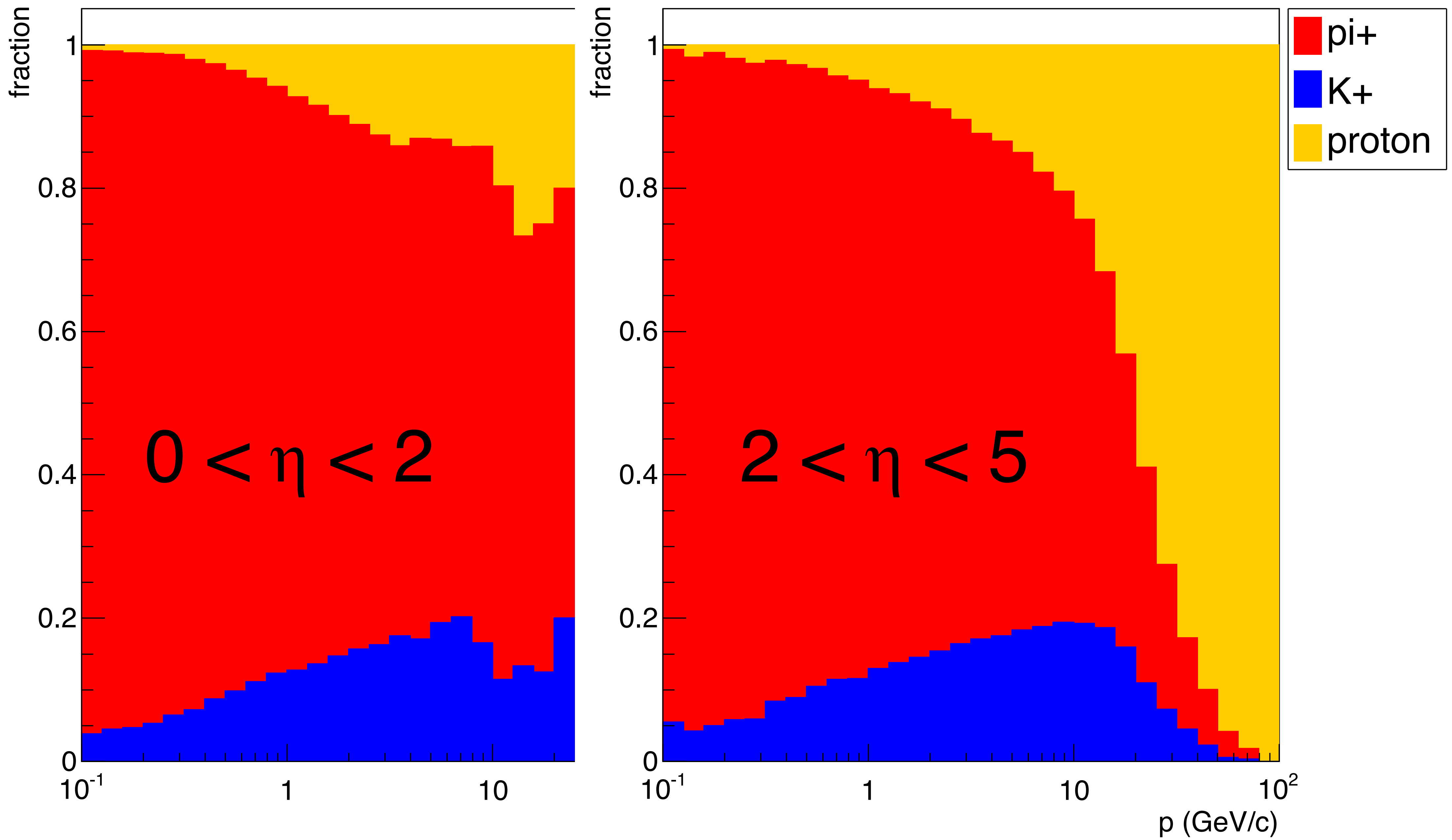
Strangeness





- Poorly known, unpolarised & polarised
  - separate (anti)strange from up/down
  - good K separation from π + p

Hadron identification



- Need good PID to pick out the kaons
  - Good ID even more important than efficiency
  - Needs **good p resolution** (see smearing talk)

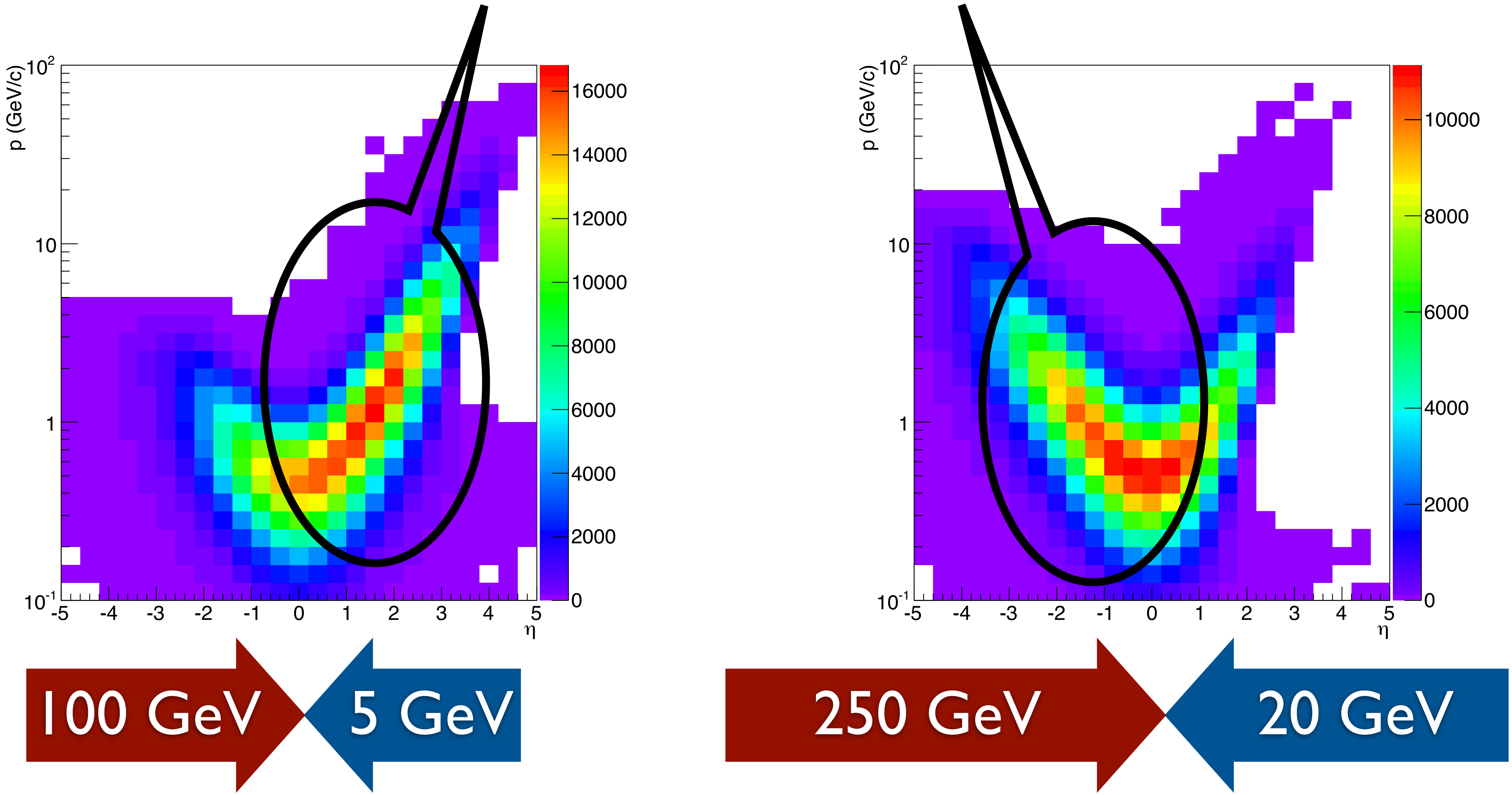
Where do we find hadrons?

Depends on **e**-**p** energy

Pion, $Q^2 > 0.1$, $z > 0.1$, $y > 0.01$

Mostly forward

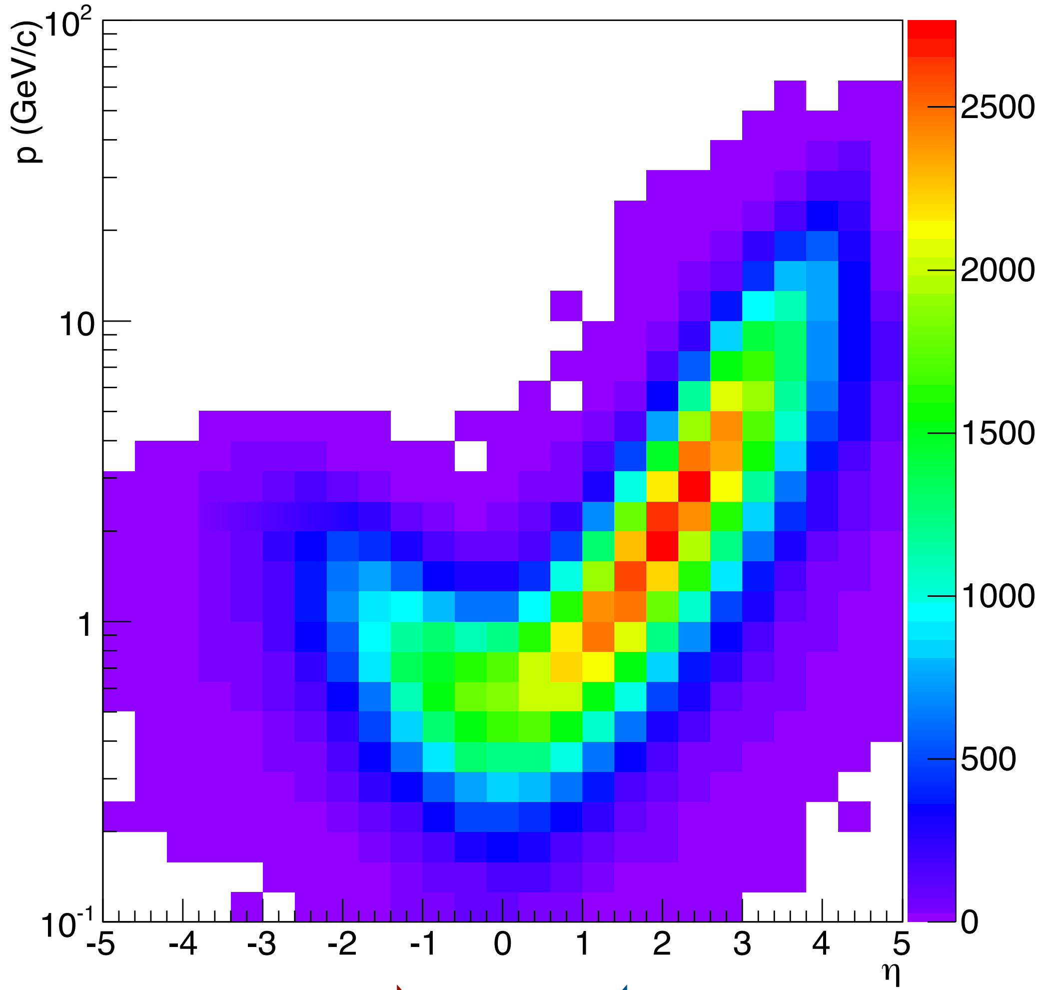
Mostly backward



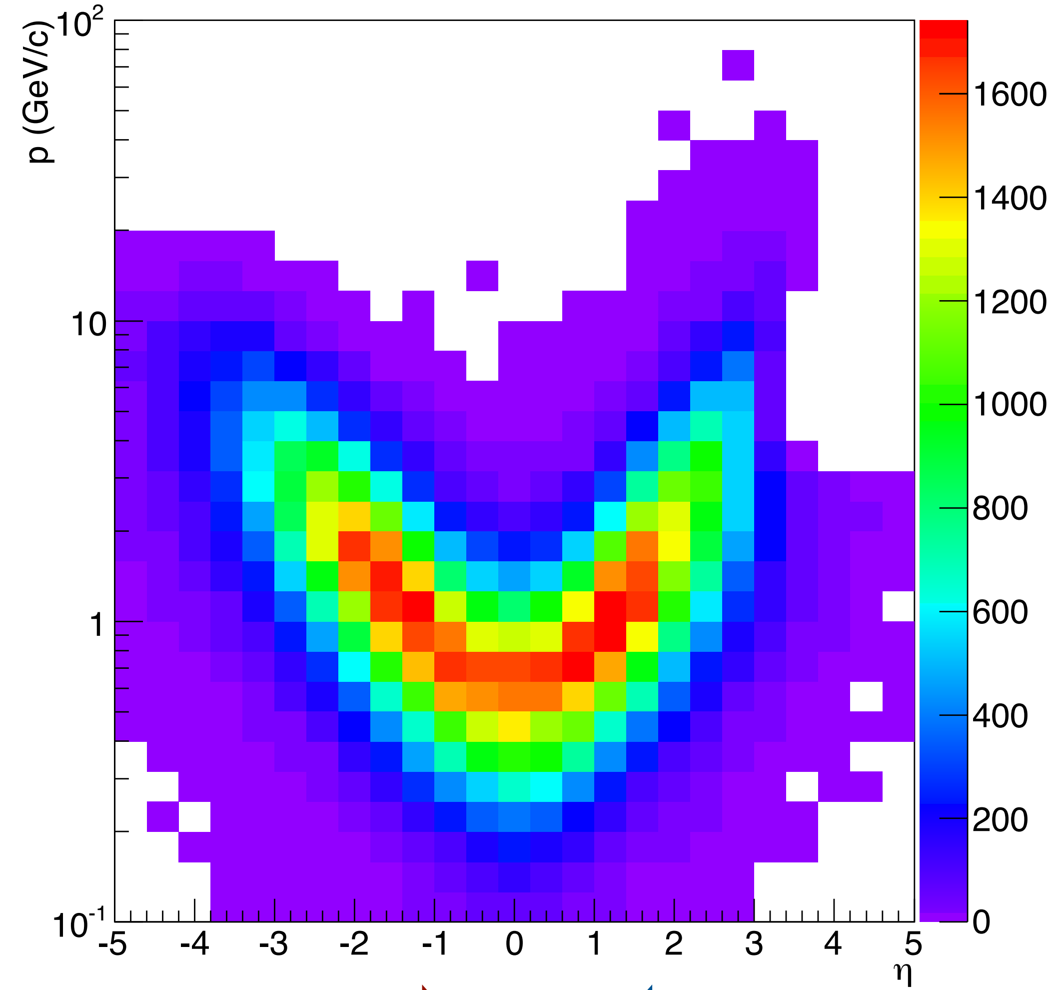
Where do we find hadrons?

Depends on
e-**p** energy

Kaon, $Q^2 > 0.1$, $z > 0.1$, $y > 0.01$



100 GeV | 5 GeV

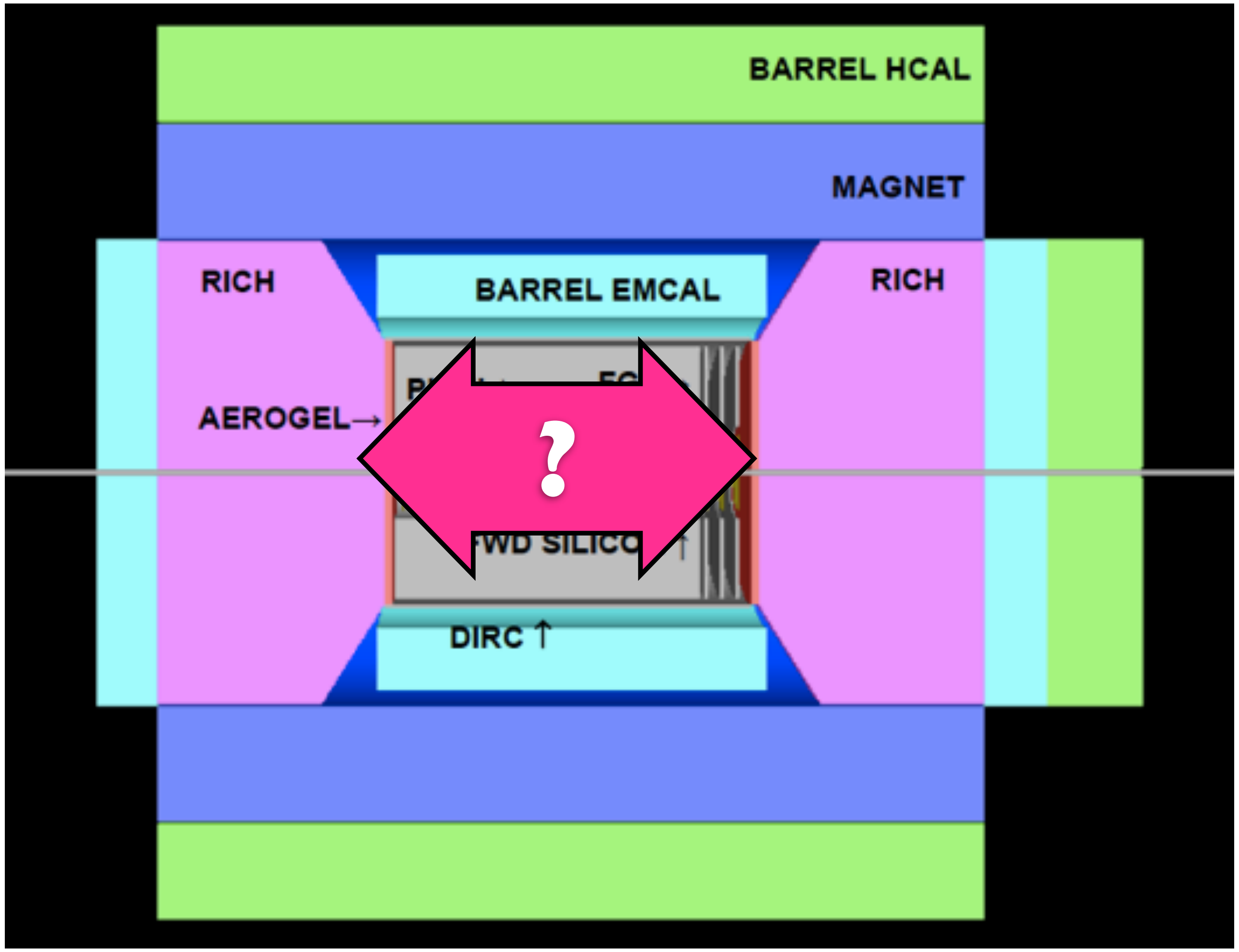


250 GeV | 20 GeV

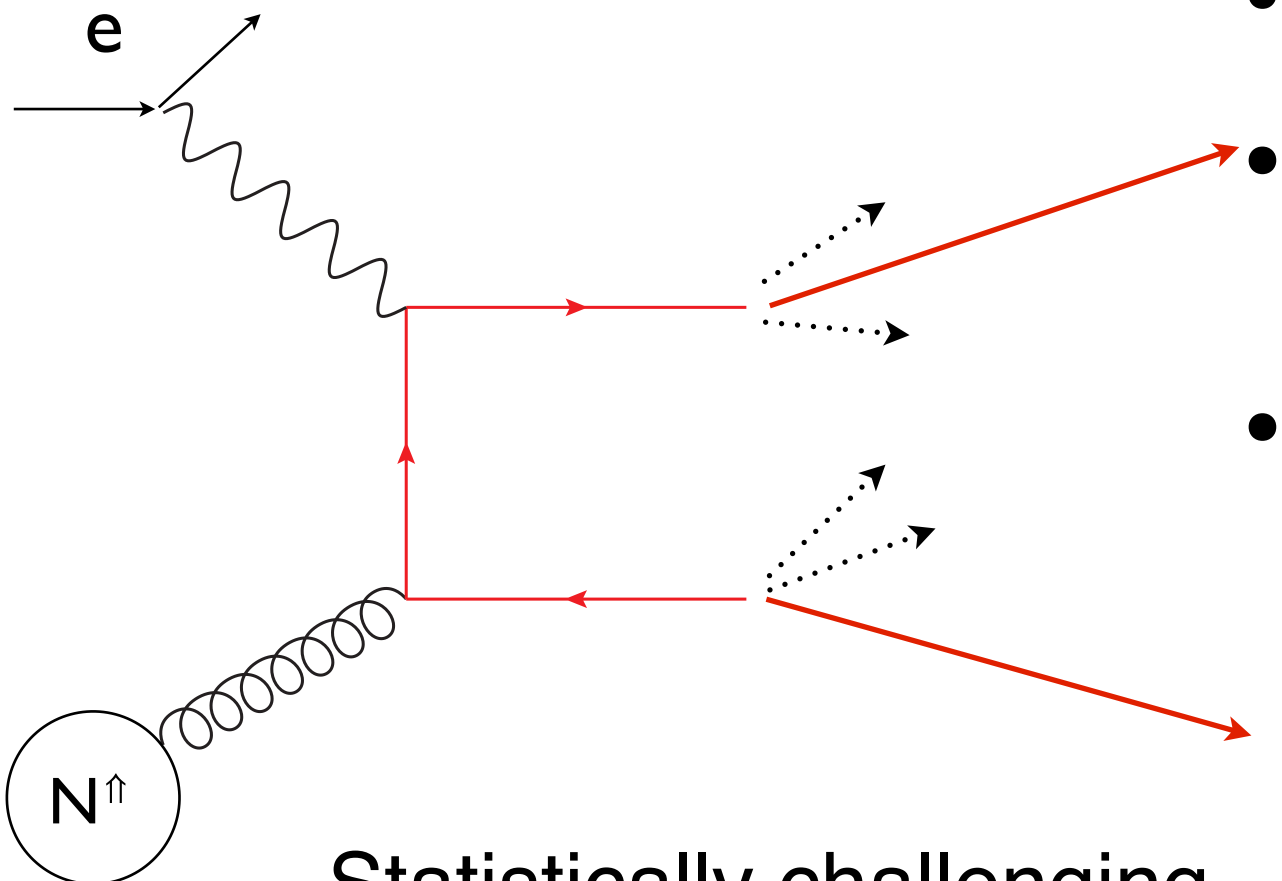
Where do we find hadrons?

- ... **everywhere**!
- **Bottom line**: tracking + PID need to cover as wide an η + p range as possible

- What does this say regarding offset vs. symmetric IP?



Charm, bottom



- e.g. gluon Sivers via D^0 pairs
- D (& esp. decay products) span wide range in η
- excellent **vertex resolution** (~few microns)

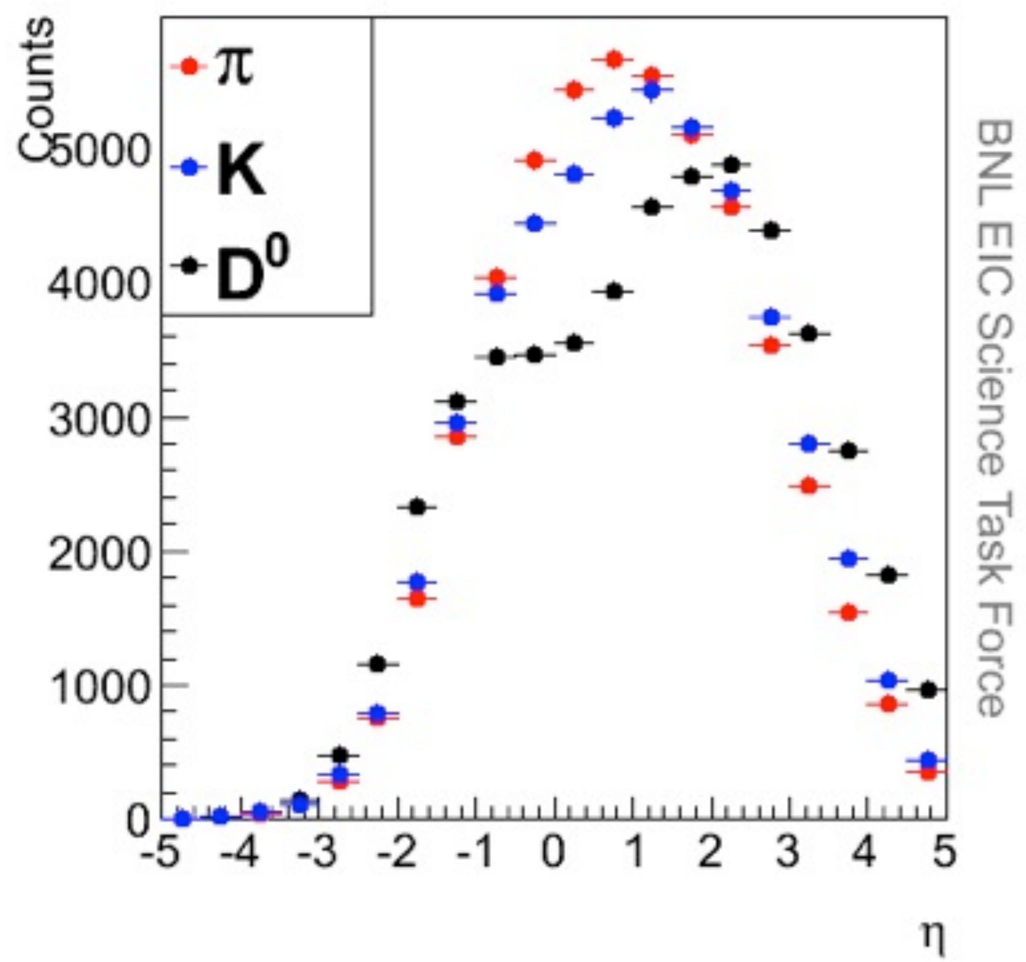
Statistically challenging (even for EIC!)

+

Multi-particle final state

=

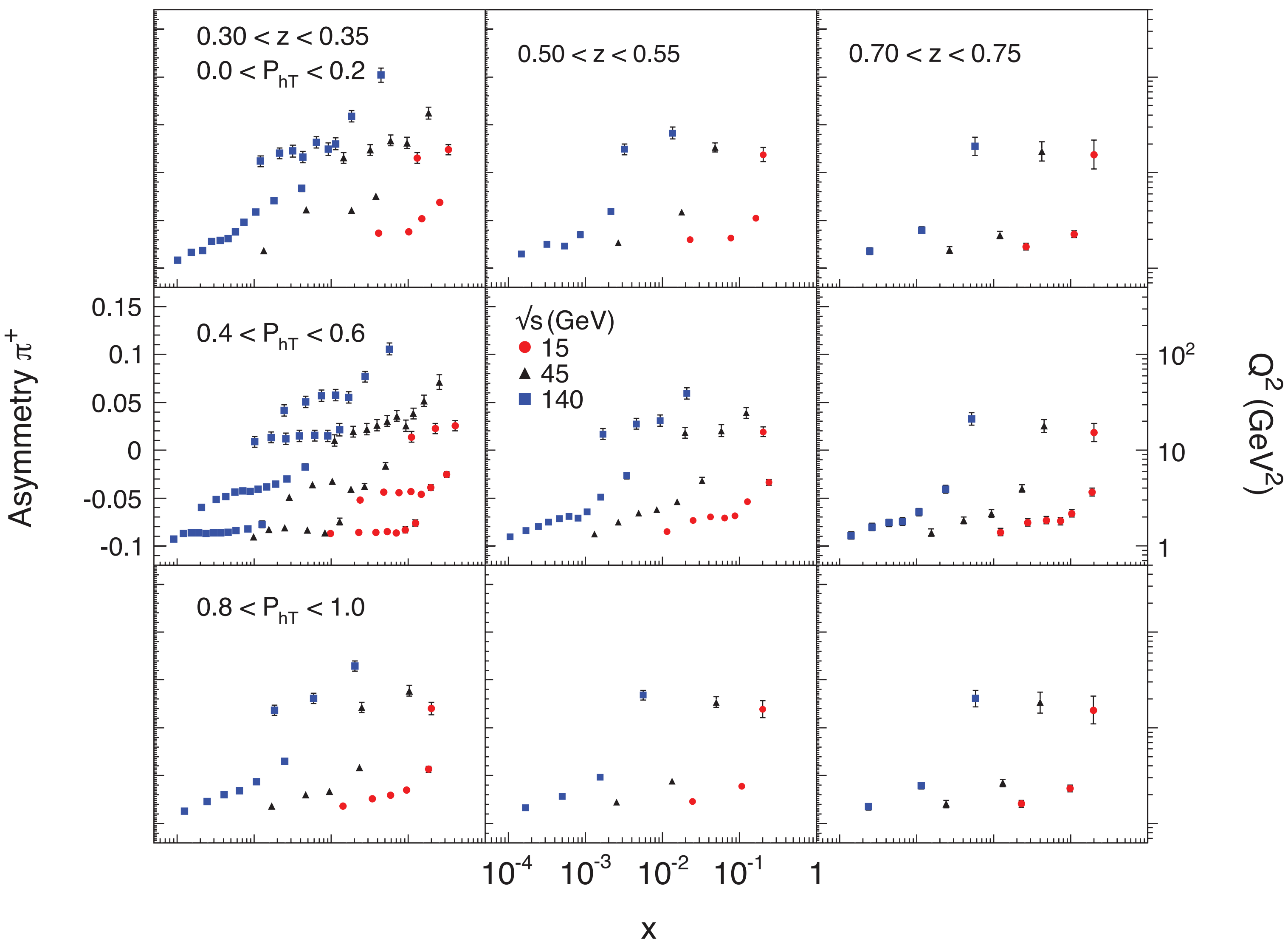
hermeticity vital



statistics vs. systematics

- High luminosity → measure **f (x, Q², z, p_T[, ϕ])**
- Even then, often systematics-limited
- **MUST** control systematics well
  - e.g. current polarisation @ RHIC: **5%** systematic
  - electron polarisation?
  - luminosity?
  - detector effects?...

Sivers asymmetry (x, Q², z, p_T)



Summary

- Good PID (π/K/p separation) crucial
  - wide momentum range
  - good momentum resolution
  - large acceptance
- Good understanding of systematics